

Research Article

## Production economics and resource use efficiency of tomato under open field condition in Kapilvastu, Nepal

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### ABSTRACT

A study was conducted in Kapilvastu district with an objective to analyze the production economics and resource use efficiency of tomato production under open field condition. Altogether ninety tomato growers were purposely selected for household survey. Primary data were collected using pre-tested interviews and focus group discussion with tomato farmers and stakeholders. Data was analyzed using SPSS and STATA, and socio-demographic characteristics, Cobb-Douglas production function and resource use efficiency of the tomato farmers was studied. The tomato production in the studied site was found to be a labor-intensive venture as cost incurred for labor was about 39 percent of the total cost with gross margin of NRs. 7255.10 per *kattha* and net profit of NRs. 5464.1 per *kattha*. Cobb-Douglas production function analysis showed positive and significant relationship of cost on labor, seed, farm yard manure, inorganic fertilizer and micronutrients and other associated expenses with the gross income. The returns to scale of 1.02 indicated increasing returns to scale whereas resource use efficiency values indicated all input resources were underutilized in tomato production.

**Keywords:** Cobb-douglas production function, resource use efficiency, tomato

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## INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is among the most widely cultivated and extensively consumed horticultural crops around the globe. In our country, tomato sits in third position after cauliflower and cabbage in terms of production area and production with 21,389 ha area and 400,674 tons of production (MOALD, 2018). Although the Terai region produces and sells more vegetables, vegetables grown in the hilly region have greater value; these vegetables are produced during the rainy season when prices are higher (NEAT, 2011). In the Hills, tomato production peaks in summer (from May to September) when it is off-season in Terai. So, only one winter season is allowed to produce tomato in open field condition in Terai.

Similarly, as per the price of tomato at Kalimati market, average prices are highest during August when there is almost no open field production and lowest during March when major supply comes from open field cultivated in Terai (KFVMD, 2014). Hence, above statements suggest that tomato growers under open field condition in Terai are in disadvantage due to seasonal restrictions, lower product value, market constraints and several underlying production problems. Shrestha, Huang & Pradhan (2015) stated that the major concern in Nepalese vegetable farming is limited resources available with the farmers, and inappropriate and inefficient use of these resources which has led to chronic inefficiency in vegetable production. Resources such as seed, chemical inputs and organic manure were found underutilized in sustainable soil management-based cauliflower in Dhading (Ghimire & Dhakal, 2014). It is thus felt necessary to analyze actual production costs and whether the inputs have been efficiently utilized which can finally put light on actual economic situation of the tomato growers under open field condition in Terai.

## MATERIALS AND METHODS

### Study site, sampling and data analysis

Two municipalities and one rural municipality of Kapilvastu district viz. Budhhabhumi Municipality, Kapilvastu Municipality and Mayadevi Rural Municipality, were purposefully selected as the study site. These sites were among the major tomato production areas of Kapilvastu district and within the working area of the Prime Minister Agriculture Modernization Project (PMAMP), Project Implementation Unit (PIU), Vegetable zone, Kapilvastu. Altogether 90 tomato growers were selected randomly for household survey – forty each from both municipalities and ten from rural municipality. Pre-tested and semi structured interview schedule was used as a tool to collect data through household survey. Similarly, focus group discussion and key informant interview was conducted; secondary data was acquired from different sources. Data thus obtained were analyzed through computer software packages like the Statistical Package for Social Science (SPSS) v.25, Microsoft Excel and STATA v.12.

### Costs and profit analysis

Total cost of tomato production was computed as the sum of all the variable and fixed costs incurred during a production period. Similarly, gross margin, net profit and benefit cost ratio was computed along with return to scale to assess the profitability.

### Production function analysis

The following form and method of Cobb- Douglas production function was used as mentioned by Rahman and Rawal (2003) in order to determine the contribution of variable costs to gross income of tomato production.

$$Y = aX_1^{b_1}X_2^{b_2}X_3^{b_3}X_4^{b_4}e^u$$

Where,

Y= Gross Income (NRs. /kattha) (1 kattha= 333.33 m<sup>2</sup>)

X<sub>1</sub>= Labor cost (NRs. /kattha)

X<sub>2</sub>= Expenditure on FYM, fertilizer and micronutrients (NRs. /kattha)

X<sub>3</sub>= Cost of seed (NRs. /kattha)

X<sub>4</sub>= other expenses incurred like tillage, plant protection, irrigation, etc (NRs. /kattha)

u = Random disturbance term

b<sub>1</sub> ...b<sub>4</sub> are the coefficient to be estimated.

The Cobb- Douglas production function in the form expressed above was linearized into a logarithmic function for ease of computation.

For the calculation of return to scale from tomato, Cobb-Douglas production function was used and calculated using formula:

$$RTS = \sum b_i$$

Where,

b<sub>i</sub> = regression coefficient of i<sup>th</sup> variables.

The sum of b<sub>i</sub> from the Cobb-Douglas production function indicates the nature of return to scale.

Return to scale decision rule:

RTS<1: Decreasing return to scale,

RTS=1: Constant return to scale,

RTS>1: Increasing return to scale.

### Resource use efficiency

The efficiency of resource use in production of tomato was determined by the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC) of variable inputs based on the estimated regression coefficients. The coefficients from Cobb-Douglas production are used in the resource use efficiency measurement (Naqvi & Ashfaq, 2013). So, efficiency of the resource was calculated by using formula:

$$r = MVP/MFC$$

Where,

r = Efficiency ratio

MVP = Marginal value product of a variable input,

MFC = Marginal factor cost (Price per unit input)

The value of MVP was estimated using the regression coefficient of each input and the price of the output.

MVP= MPP x<sub>i</sub> × P<sub>y</sub>(Unit price of output)

$$MPPx_i = b_i * \left( \frac{Y}{\bar{x}_i} \right)$$

But,

Where; b<sub>i</sub>= Estimated regression coefficient of input X<sub>i</sub>

$\bar{Y}$  = Geometric mean value of output

$\bar{X}_i$  = Geometric mean value of input being considered

The prevailing market price of input was used as the Marginal Factor Cost (MFC).

$MFC = P_{x_i}$

Where,

$P_{x_i}$  = Unit price of input  $x_i$ .

The decision rule for the efficiency analysis was as:

$r=1$ ; Efficient use of a resource

$r>1$ ; Underutilization of a resource

$r<1$ ; Overutilization of a resource

## RESULTS AND DISCUSSION

### Socio-demographic characteristics

As inferred from the table 1, the average family size was higher than the district average 6.26 (CBS, 2012) with majority of household being male headed. Literacy rate of the sampled population was closer to the district average of 54.9 percent and dependency ratio was 0.65. Almost all stated agriculture as their major source of income. Similarly, about 67 percent were involved in group and cooperatives while 42 percent had received some sorts of training on vegetable production.

**Table 1. Socio-demographic characteristics of the sampled household**

Socio-demographic characteristics	Value	Socio-demographic characteristics	Value
Mean age of respondent(yrs)	43.73	Male headed household	86 (95.60)
Mean age of household head (yrs)	51.90	Literacy rate of sampled population	466 (50.93)
Population distribution		Religion	
Male	477 (52.13)	Hindu	73 (81.10)
Female	438 (47.87)	Muslim	17 (18.90)
Average family size	10.17	Land holding (in kattha)	
Age distribution		Total owned land	29.15
Active population (16-59 yrs)	554 (60.55)	Leased in land	10.57
Dependent population	361 (39.45)	Area under tomato	3.25
Dependency ratio	0.65	Institutional characteristics	
Family type		Member of group/cooperatives	60 (66.67)
Nuclear	49 (54.44)	Training on vegetable production	38 (42.20)
Joint	41 (44.66)	Organizational support	37 (41.10)

*Figures in parentheses indicate percentage*

### Economic analysis of tomato production

Tomato production requires majority of labor in harvesting and manures and chemical application. The mean labor use in harvesting was found to be 3.16, manures and chemical application was found 2.56 per kattha (Table 2). Labor for harvesting contributes about 27.77 percentage of total labor requirement followed by manure and chemical application which contribute 22.47 percentages. Thus, the total mean labor required for tomato production in a season was 11.41 per kattha with standard deviation of 3.54.

Higher labor share for harvesting can be backed with the fact that harvesting fresh tomatoes is labor intensive and requires multiple picking. Kurosaki, Ohmori, Hamamoto & Iwasaki (2014) in their study stated that longest work activity in large scale tomato production in Japan was

harvesting which accounted for 31percent of annual work time. Bayramoglu, Gundogmus & Tatlidil (2010) also found that harvesting operation accounts for 34.98 percent of total labor use in tomato production.

**Table 2. Labor use in tomato production per kattha in the study area**

Labor (man days / kattha)	Mean Numbers( $\pm$ SD)	Percentage use
Nursery raising	0.66 $\pm$ 0.28	5.69
Transplantation	0.83 $\pm$ 0.29	7.25
Manures, chemical application	2.56 $\pm$ 0.91	22.47
Land preparation & intercultural	1.72 $\pm$ 0.89	15.13
Irrigation	1.26 $\pm$ 0.52	11.02
Weeding	1.22 $\pm$ 0.50	10.67
Harvesting	3.16 $\pm$ 1.13	27.77
Total	11.41 $\pm$ 3.54	100.00

The study revealed that majority of cost incurred for human labor. The mean cost for the human labor was Rs. 6274.71 per kattha followed by cost for manures (FYM), chemical fertilizer and micronutrients which was 2965.68 per kattha. The fixed cost incurred during the production period was Rs 1791 per kattha which include land rent, interest on variable cost and tax.

**Table 3. Cost on different items of tomato production per kattha in the study area**

Items	Mean
Variable costs	
Labor cost (Rs)	6274.71 (39.20)
Cost on FYM, fertilizer and micronutrients (Rs)	2965.68 (18.53)
Cost on seed (Rs)	627.14 (3.92)
Cost on tillage, irrigation fuel and plant protection (Rs)	2048.12 (12.80)
Other costs (staking, equipment, etc.)	2299.03 (14.36)
Fixed costs	
Interest on tomato production (Rs)	924.00
Land rent including tax (Rs)	867.00

*Figure in parentheses indicates percentage of total cost*

Gross margin of tomato production was calculated by deducting the total variable cost from the gross return and was found Rs.7255.1 per kattha (Table 4). By deducting the total cost from gross revenue, the net profit was calculated and found Rs.5464.1 per kattha. MRSMP (2016), in their report stated the net profit in main season tomato cultivation in open field condition of Bhaktapur was Rs. 265833.1 per hacter which accounts for Rs. 8861.1 per kattha. Similarly, SARPD (2016) had reported similar net profit of Rs. 8500 per kathha for Terai in open field condition.

**Table 4. Gross margin and profit analysis of tomato production in the study area**

Particulars (NRs./kattha)	Mean
Fixed cost	1791.00
Total variable cost	14214.75
Total cost	16005.75
Total revenue	21469.84
Gross margin	7255.10
Net profit	5464.10

Benefit cost ratio was calculated simply as the ratio of total benefit which accounts for gross revenue to the total cost and was found to be 1.34. The result of B:C ratio was greater than unity which indicates that investment in tomato production was economically viable. Kafle and Shrestha (2017) found B/C ratio from the second year onward to be 1.65 from the case study of tomato cultivation in Hemja, Kaski.

### Factors contributing to gross revenue from tomato

From the linearized form of Cobb Douglas Production Function, contribution of variable factors to the gross income of tomato production was computed and found that the labor cost, cost on seed, cost on FYM, fertilizer and micronutrients, and other associated cost incurred, all showed positive and significant relation with gross income.  $R^2$  of the model was 0.65 which indicates that 65% of variation in gross income was explained by the independent variables.

**Table 5. Estimated coefficients and statistical analysis of Cobb-Douglas production function of tomato production in the study area**

Explanatory variables	Coefficient	Standard error	t-value	p>/t/
Constant	1.696	0.753	2.25	0.027
Labor cost ( $X_1$ )	0.482	0.108	4.47***	0.001
Seed cost ( $X_2$ )	0.108	0.056	1.93*	0.057
Expense on manure, fertilizer and micronutrients ( $X_3$ )	0.191	0.051	3.76***	0.001
Other associated expenses ( $X_4$ )	0.242	0.074	3.28***	0.002
$R^2$	0.651			
Adjusted $R^2$	0.632			
F value	39.75			

‘\*\*\*’, ‘\*\*’ and ‘\*’ indicates statistically significant at 1%, 5% and 10% level of significance, respectively

According to Farrel (1957), the elasticity of production which is the ratio of a percentage change in output to percentage change in input is used to calculate the return to scale which is a measure of a firm's success in producing maximum output from a set of input. Returns to scale was calculated as the sum of individual inputs elasticities. The return to scale was 1.02 which means that increase in all the inputs by a factor of one percent would increase output by 1.02 percent which is increasing return to scale. In contrast, Kunwar & Maharjan (2019) found decreasing return to scale of 0.415 in off-season tomato production under poly-house in Okhaldhunga, Nepal.

### Resource use efficiency

The individual input elasticities as obtained from Cobb-Douglas production function analysis was used for the computation of resource use efficiency. From the study, it is revealed that all the resources used were underutilized in tomato production. Resources used such as seed, hired labor, fertilizer, etc are underutilized in tomato production in Ghana (Tambo & Gbemu, 2010) and Nigeria (Saleh, Kajidu, & Abubakar, 2016).

**Table 6. Estimated resource use efficiency of tomato production in the study area**

Expenses (NRs/Kattha)	GM	Coefficient	MVP	MFC	r	Efficiency
Labor	6038.94	0.482	1.618	1.00	1.62	Under utilized
Seed	570.34	0.108	3.795	1.00	3.80	Under utilized
Manure & fertilizers	2568.83	0.191	1.505	1.00	1.51	Under utilized
Others	1927.99	0.242	2.507	1.00	2.51	Under utilized



## CONCLUSION

Although the productivity of tomato in the surveyed site is higher than the national average, there is still plenty of room for improvement in technical and resource allocation aspect in order to increase the productivity and maximize profitability. Labor costs, cost on seed, costs on FYM, fertilizer and micronutrients and other expenses have significant contribution on the gross income. The tomato enterprise was profitable as shown by the returns to scale analysis. The resources used in tomato production were found underutilized and proper utilization of resources is necessary.

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## Authors contribution

M.S. designed and conducted the survey, analyzed data and prepared the manuscript; M.P., R.K.O. and B.A. helped and supervised survey, data analysis and manuscript preparation.

## Conflict of interest

The authors declare no conflicts of interest regarding publication of this manuscript.

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